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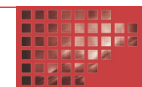
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## Computerized physician order entry (CPOE) system: expectations and experiences of users

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### Keywords

CPOE system, expectations, experiences, implementation

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### Abstract

**Objectives** To explore physicians' and nurses' expectations before and experiences after the implementation of a computerized physician order entry (CPOE) system in order to give suggestions for future optimization of the system as well as the implementation process.

**Method** On four internal medicine wards of two Dutch hospitals, 18 physicians and 42 nurses were interviewed to measure expectations and experiences with the CPOE system. Using semi-structured questionnaires, expectations and experiences of physicians and nurses with the CPOE system were measured with statements on a 5-point Likert scale (1 = completely disagree, 5 = completely agree). The percentage respondents agreeing (score of 4 or 5) was calculated. Chi-squared tests were used to compare the expectations versus experiences of physicians and nurses and to assess the differences between physicians and nurses.

**Results** In general, both physicians and nurses were positive about CPOE before and after the implementation of this system. Physicians and nurses did not differ in their views towards CPOE except for the overview of patients' medication use that was not clear according to the nurses. Both professions were satisfied with the implementation process. CPOE could be improved especially with respect to technical aspects (including the medication overview) and decision support on drug–drug interactions.

**Conclusion** Overall we conclude that physicians and nurses are positive about CPOE and the process of its implementation and do accept these systems. However, these systems should be further improved to fit into clinical practice.

### Introduction

With the introduction of computerized physician order entry systems (CPOE) in an increasing number of hospitals the electronic way of medication ordering is becoming more common. The shift from a paper-based to a computerized system affects clinical practice [1]. Mainly based on experiences in the USA we know that CPOE has benefits in comparison with a paper-based system; more structured and legible medication orders [2] and clinical decision support during the prescribing phase. These ben-

efits have been shown to contribute to a reduction in the number of medication errors identified in studies that evaluated the impact of CPOE on medication safety [3–5].

However, disadvantages are also known such as rigidity of the system [6], negative effect on the collaboration between physicians and nurses [7,8] and new types of medication errors introduced by the system [9]. Most studies, however, show that these disadvantages are outweighed by the advantages, leading to increased medication safety. In order to achieve such a positive effect, the system should be successfully implemented taking into

account the views, needs and acceptance of the users, i.e. the physicians and nurses [1,10]. Evaluation of the impact of the system enables improvements and adaptations [1,10,11].

The aim of this study was to explore physicians' and nurses' expectations before and experiences after the implementation of CPOE in order to give suggestions for future optimization of the system and its use as well as suggestions for the implementation process.

## Methods

### Setting and design

This survey study was conducted in two medical wards of the 1300-bed University Medical Center Groningen (UMCG) (a general internal medicine and a gastroenterology/rheumatology ward) and in two medical wards of the 600-bed teaching hospital 'TweeSteden' in Tilburg and Waalwijk (TSh) (a geriatric and a general internal medicine ward), The Netherlands. Health care professionals were surveyed at two time points. In both hospitals, the first survey was conducted towards the end of 2005 prior to implementation of CPOE. The second survey was conducted after CPOE was implemented; for TSh in the summer of 2006 and for UMCG towards the end of 2006 (internal medicine) and in April/May of 2008 (gastroenterology/rheumatology).

### Paper-based system versus CPOE

Before the implementation of CPOE on the four medical wards the medication ordering system was paper based. Physicians wrote prescriptions on forms and nurses transcribed these prescriptions on special administration charts which they used during the process of dispensing and administering.

Following the introduction of CPOE the medication ordering process is computerized. Physicians prescribe the medication in a standardized way. They have to select drugs from menus and are required to fill in various prescription characteristics. Furthermore, during the prescribing phase drug safety alerts are generated in case of overdoses and drug-drug interactions. In the two hospitals different CPOE systems are used. The UMCG uses the commercially sold system Medicator (ISOFT, Leiden, The Netherlands) in contrast to the TSh where the partly home-grown system Theriak (Theriak evf, Tilburg, The Netherlands) is used. In the Medicator system only the prescribing phase is computerized (the registration for the dispensing and administration purposes is still paper-based) in contrast to the Theriak system in which also the patient identification and administration phase is automated.

### Implementation of CPOE

The boards of directors of both hospitals enforced their medical wards to implement CPOE. Both hospitals had a systematic approach for the implementation of CPOE. The implementation process was performed by an implementation team consisting of information and communication technology and hospital pharmacy staff. In the UMCG the process took 17 weeks per medical ward. In the TSh it took 10 weeks. Before the implementation the current situation (organizational aspects of the medical ward, procedures and processes) was assessed, technical adjustments were

made and physicians and nurses were introduced to and trained in the use of the system. This introduction was different in both hospitals: demonstrations in the UMCG (passive learning) versus real practicing in prescribing (active learning) in the TSh. During the actual implementation, the implementation team was available to answer questions and solve problems. Finally, the implementation team evaluated the implementation process in a session at each ward with physicians and nurses.

### Study population and procedure

The study population consisted of physicians and nurses working on the four study wards. The population was a convenience sample of residents and fellows in internal medicine, specialists, head nurses, coordinating nurses and regular nurses. Per ward at least one supervising specialist and one resident/fellow were approached for the study as well as the head nurse, one coordinating nurse and one regular nurse. The head nurse was asked who of the other nurses had time to participate in the study. Most residents and fellows worked temporarily on a ward and could only be contacted either in the pre- or post-intervention period. The group of respondents in the baseline-period was not the same as in the post-intervention period except for the head nurses. The participants were surveyed in a face-to-face interview by one of three researchers (KV, RZ, JvD).

### Questionnaire/interview instrument

Two semi-structured questionnaires were developed targeting physicians and nurses respectively. These surveys were constructed to measure expectations and (composed in a slightly different format) to measure experiences with CPOE.

The overall attitude towards the handwritten and CPOE system was measured by the question 'What is your overall opinion about the paper-based system respectively CPOE system?' Respondents could answer 'fine/moderate/neutral/has constraints/completely outdated' for the paper-based system and 'fine (no need for changes)/moderate (there are still some bugs)/neutral/has constraints/does not meet the requirements' for CPOE.

Expectations and experiences with CPOE were measured with statements using a 5-point Likert scale, ranging from 1 = completely disagree to 5 = completely agree. In an open-ended question respondents were asked to mention advantages as well as disadvantages of the system.

The respondents were asked in structured questions about the preparation, quality and duration of the support from the implementation team. For these questions, also a 5-point Likert scale was used.

### Data analysis

For the statements the percentage respondents agreeing (score of 4 or 5 on the Likert scale) was calculated. Chi-squared tests were used to compare expectations versus experiences of physicians and nurses and to assess differences between physicians and nurses.

The overall positive view towards CPOE was assessed as a sum score of eight statements before as well as after the implementation of CPOE: negative statements were recoded into positive statements and the mean number of positive scores over all

respondents was calculated. Only the statements were included that were asked both before and after the introduction of CPOE and to both physicians and nurses. A *t*-test was used for assessing differences in the overall positive view towards CPOE between the two periods. All analyses were performed using SPSS version 14 (SPSS, Chicago, IL, USA).

## Results

A total of 18 physicians (seven supervising specialists and 11 residents/fellows) and 42 nurses were interviewed (Table 1). The size of the groups before and after the implementation of CPOE was approximately the same for both the physicians and nurses. In

the TSh more physicians were surveyed than in the UMCG (12 versus 6), whereas in the UMCG more nurses were included (23 in the UMCG versus 19 in the TSh).

The overall attitude of most physicians and nurses towards the paper-based system was negative (Fig. 1). The system was considered to have constraints and to be completely outdated. In contrast most physicians and nurses experienced CPOE more positively, although they considered it not to be optimal yet because of some technical bugs (Fig. 2).

### Physicians

Physicians had positive expectations of CPOE being able to reduce prescribing errors and to give an improved overview of patients' medication use which was in line with their experience with CPOE once they had started working with it (Table 2). This was in contrast to the physicians' expectations and experiences with the time it would take to prescribe medication orders by use of CPOE. It turned out to take less time than they had expected. They were neutral before as well as after the implementation of CPOE on the speed with which medication orders were communicated to the nurses and about how well their fellow physicians handled the system. The way nurses used the system exceeded physicians' expectations although the difference with their expectations was not significant. Physicians expected CPOE to give good clinical support on drug–drug interactions but their experiences were less positive (again the difference was not significant). Physicians stuck to their opinion that CPOE still has some technical glitches.

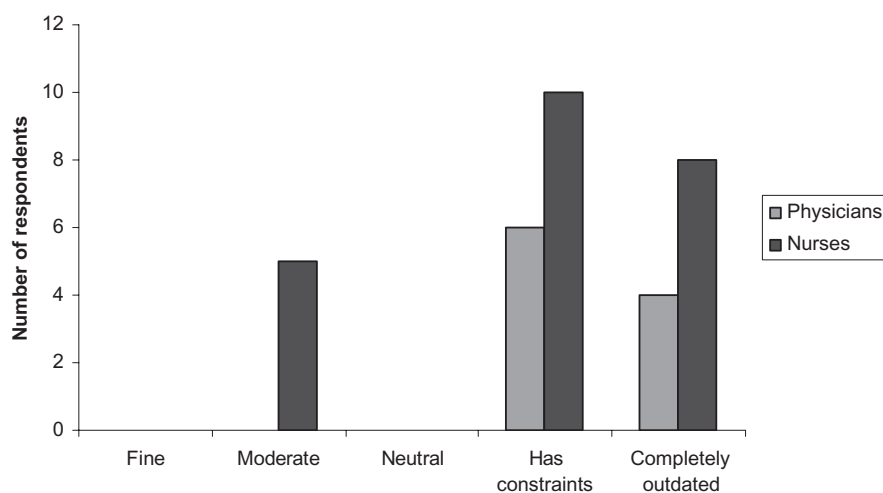
### Nurses

Nurses experienced CPOE to improve the clarity of the prescriptions just as they had expected (Table 2). They were positive about the way their fellow nurses cope with the system. Also they were rather positive about CPOE reducing errors in prescribing. Their experiences with the support of CPOE in preventing drug–drug interactions as well as how they experienced that physicians used the system turned out to be significantly worse than their expectations before. A minority of the nurses was positive about the speed with which they were informed about the medication orders.

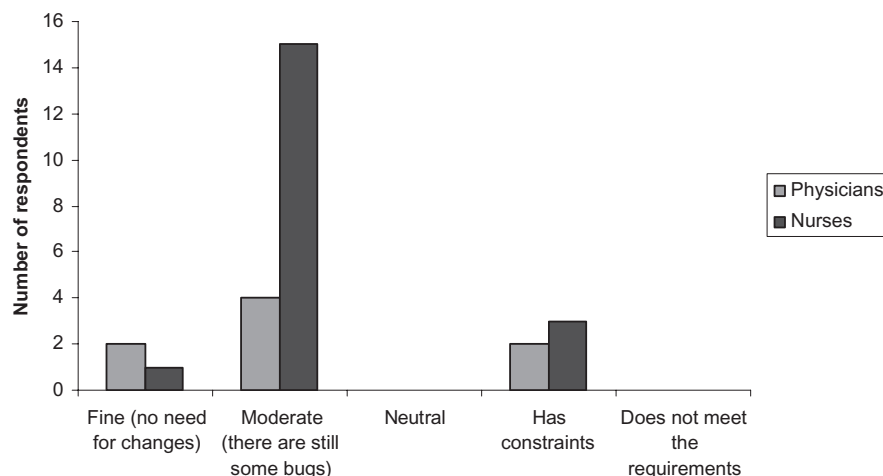
**Table 1** Characteristics of respondents

	Paper-based system	CPOE
Physicians		
<i>n</i> (total = 18)	10	8
Sex		
Female/male	5/5	3/5
Profession		
Resident	1	2
Fellow	5	3
Specialist	4	3
TSh	6	6
UMCG	4	2
Nurses		
<i>n</i> (total = 42)	23	19
Sex		
Female/male	17/6	18/1
Profession		
Head nurse	5	4
Coordinating nurse	8	7
Nurse	10	8
TSh	9	10
UMCG	14	9

TSh, 'TweeSteden' hospital; UMCG, University Medical Center Groningen.



**Figure 1** Overall attitude of physicians/nurses towards paper-based system.



**Figure 2** Overall attitude of physicians/nurses towards computerized physician order entry system (CPOE).

**Table 2** Expectations and experiences with computerized physician order entry system (CPOE)

	Physicians			Nurses		
	Expectations* (n = 10) (%)	Experiences* (n = 8) (%)	P value†	Expectations* (n = 23) (%)	Experiences* (n = 19) (%)	P value†
By the introduction of CPOE . . .						
Positive statements						
Fewer errors in prescribing	100	75	0.09	83	68	0.28
A new medication order is sooner known to the nurses	40	50	0.67	26	42	0.27
A better overview of patients' medication use	90	88	0.87	61	37	0.12
A good support for preventing of drug–drug interactions	80	50	0.18	96	74	<b>0.04</b>
More clear which medication/dosage the patient should get	–‡	–‡	–	87	84	0.80
The system is user-friendly enough to prescribe in an efficient way	–‡	88%	–	–‡	–‡	–
Negative statements						
Many (colleague) physicians do not handle the system well, which causes problems	30	50	0.39	44	74	<b>0.05</b>
Many (colleague) nurses do not handle the system well, which causes problems	50	13	0.09	48	32%	0.29
Prescribing takes a lot of time	70	13	<b>0.02</b>	–‡	–‡	–
There are still many technical glitches	80	63	0.41	87	47	<b>0.01</b>

\*Expressed as percentage agreeing [positive is defined as scores 4 and 5 on a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree)].

†P values refer to chi-squared tests for nominal variables.

‡Not asked.

This was found both before (expectations) and after (experiences) the implementation of CPOE. Less technical glitches were experienced than expected, although these glitches are still considered to be a problem.

### Physicians and nurses

No significant differences between the views of physicians and nurses were identified except for the overview they had of patients' medication use in CPOE which nurses experienced as not good in contrast to the physicians who experienced it as good.

No significant differences were identified in the sum score of positive views towards CPOE (mean of the number positive answered items) before and after the implementation for physicians (mean before = 4.80, mean after = 5.25,  $P = 0.46$ ) and for nurses (mean before = 4.74, mean after = 4.53,  $P = 0.63$ ). There

were also no differences between professions in their overall positive expectations (mean physicians = 4.80, mean nurses = 4.74,  $P = 0.91$ ) nor in their overall positive experiences (mean physicians = 5.25, mean nurses 4.53,  $P = 0.20$ ).

The respondents in both hospitals were satisfied with the implementation process, despite the different approaches used (Table 3). Most of the physicians and nurses reported to be sufficiently prepared to start working with the system. Most professionals present during the implementation process were satisfied with the availability and the available support of the implementation team.

In Box 1 the most frequently mentioned advantages and disadvantages of CPOE are listed. According to the respondents the system improved the efficiency of the medication process and improved the readability of the prescriptions. However, there were still many technical glitches.

**Table 3** Experiences with the implementation process

	Physicians ( <i>n</i> = 8)	Nurses ( <i>n</i> = 19)
You were sufficiently prepared to work with the system?	75% *	90% *
Only for persons who were working at the ward during the implementation	( <i>n</i> = 4)	( <i>n</i> = 18)
There was enough support from the implementation team during the implementation phase.	100% *	94% *
The implementation team was sufficiently available to give support.	100% *	94% *

\*Expressed as percentage agreeing (positive is defined as scores 4 and 5 on a 5-point Likert scale (1 = strongly disagree and 5 = strongly agree).

#### Box 1 Most listed advantages and disadvantages of CPOE

##### Advantages

'System gives a good overview of used medication' (13 times)  
 'System is efficient' (13 times)  
 'Readability is improved' (11 times)  
 'Fewer medication errors than before' (9 times)  
 'Introduction of CPOE results in better logistics' (only UMCG) (7 times)  
 'Clinical decision support is incorporated' (6 times)

##### Disadvantages

'Still many technical glitches' (9 times)  
 'Dependence on physicians' (only nurses) (6 times)  
 'System does not give a good overview of used medication' (6 times)  
 'Too many irrelevant drug-drug interactions' (3 times)  
 'It is a slow system' (3 times)  
 'Logistics got worse' (only TSh) (2 times)

## Discussion

Physicians and nurses were more positive about CPOE than the paper-based medication ordering system. They were also satisfied with the way the system was implemented. In general, their ideas about CPOE before implementation were comparable to their experiences. Even before implementation, a high degree of acceptance of CPOE existed on the work floor which undoubtedly facilitated the actual implementation and adoption. Coupled with the view of professionals that the paper-based system was outdated, this provides good conditions for change [12]. At the same time we have to bear in mind that the use of CPOE was decided at the top of the organization and once implemented there was no choice at the work floor whether to use CPOE or not.

The most surprising difference between expectations and experiences is with respect to the time investment of prescribing. Prescribing by use of CPOE took less time than the physicians thought it would take. This is in contrast to earlier studies showing that physicians were annoyed with the additional time required for computerized prescribing in comparison with the handwritten way of prescribing [13,14]. Our more positive findings may be explained by the more user-friendly interfaces that are being used nowadays in comparison with the systems in the 1990s described in earlier studies.

In contrast to physicians, nurses were negative about the overview they had of patients' medication use in CPOE. According to them these overviews were not clear. This is certainly a point of interest, because it affects the work process of nurses in a negative way and it can lead to medication errors. Furthermore, the nurses were negative about the way physicians handled CPOE. This may be caused by a change in the way nurses and physicians collaborate since the introduction of CPOE as has been described elsewhere [8,15]. It is known that in paper-based systems, nurses and physicians interact more easily and efficiently with respect to patient's condition and medication [8]. In the CPOE system such interaction is less easy because it separates the

work of physicians from that of nurses; the prescribing phase takes place behind a computer with less feedback or information from nurses. Nurses become more dependent on the way physicians prescribe and they have less opportunity to correct physicians' actions.

This study showed that the decision support on drug-drug interactions in CPOE needs more attention. Because in the paper-based system there was limited decision support during the prescribing phase, nurses' and physicians' expectations about decision support were high. However, these expectations were not met. The main reason is the generation of too many safety alerts which are not appropriate for the hospital setting. Improvement is needed before 'alert fatigue' occurs, which can lead to ignorance of important alerts besides the unimportant ones [16]. Future research should investigate what the best approach is, as turning off alerts hospital-wide can be problematic because of differences in clinical relevance for the various medical specialties and differences in knowledge [17].

Despite the difference in strategies for implementing CPOE between both hospitals, physicians and nurses from both hospitals were satisfied with the duration and quantity of the support given by the implementation team. This suggests that both strategies were adequate approaches to implement CPOE, at least well fitted in their context.

The main limitation of this study is the difference in study sample before and after the implementation of CPOE, i.e. few respondents were interviewed twice. Another limitation is the use of a convenience sample instead of a randomized sample. It is possible that our respondents were more willing to participate than other users because they had a clear view towards CPOE, whether positive or negative. A strength of our study is the setting of two hospitals (a university and a teaching hospital) with two different CPOE systems. This enhances the generalizability of our results.

Despite the positive experiences with CPOE, the system does not function optimally yet. Based on the results of this study a



number of recommendations can be made on how to optimize the system. First technical glitches should be fixed with a special interest for improving the display of medication overviews for nurses. These glitches are still one of the most frequently mentioned disadvantages of CPOE. Furthermore, the decision support on drug–drug interactions should be improved in the sense that an assessment should be made on which safety alerts are really relevant for the hospital setting and which safety alerts should be turned off for each medical specialty separately. Finally, physicians and nurses should be aware that CPOE has an impact on their collaboration and that during the prescribing process nurses are more dependent on physicians than before. In this situation it is important to guarantee good communication between both professions. Hospitals aiming to start implementing CPOE must take into account these recommendations to guarantee an optimal use of their CPOE system.

Overall we may conclude that physicians and nurses are positive about CPOE and the process of its implementation and do accept these systems. However, these systems should be further improved in order to fit into clinical practice.

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